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GYPSUM DEPOSITS IN NORTHERN MANITOBA.

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On the Little Saskatchewan River, which carries the overflow of Lake Manitoba into the western side of Lake Winnipeg, there is a comparatively small shallow lake which has been known since the time of the early voyageurs as Lake St. Martin. It lies in latitude, $51^{\circ} 30'$, longitude, $98^{\circ} 40'$, has an area of 115 square miles, a greatest depth of about fifteen feet, and an approximate elevation above the sea of 790 feet.

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Lying to the north-west of this lake, there is an area of level or very gently sloping country, which is now covered by extensive natural meadows, separated by groves of poplar and birch, as well as occasional forests of spruce and tamarac. This country is as yet in its native beauty, being entirely untouched, either by the woodman's axe or the plough of the farmer; but the time cannot be far distant when a thriving agricultural population will occupy the district, reaping from the fertile soil bountiful and continuous harvests.

In the early part of the past summer, the writer made a short journey on foot into this country, from the shore of the lake, in order to determine the question of the existence or non-existence of beds of gypsum in the vicinity.

Starting from the north-west corner of the Indian Reserve at present held by the Saskatchewan Band of Saulteaux Indians, we travelled in a general north-westerly direction for five miles, till we reached a rounded gravel ridge, rising from fifteen to twenty feet above the general level of the country to the north-west of it, and along the foot of which, on the alluvial plain, are scattered numbers of rounded, weather-worn, gneissoid erratics. This ridge represents a beach of the extended Lake Winnipeg, called by Mr. Warren Upham Lake Agassiz, when it covered the whole of this area, and when the surrounding fertile alluvial deposits were being laid down near its gradually receding shore. The height of this ridge, as shown by aneroids read simultaneously on it and on the lake, is about 840 feet, being fifty feet above Lake St. Martin, and thirty feet above Lake Manitoba. Its chief interest, however, did not centre in the fact that it had once represented a lake-shore line, for these shore-lines are very commonly to be met with in all this apparently level Manitoba plain, but that in little holes and caves in it were to be seen small exposures of soft, compact, snow-white gypsum.

Following the ridge, still in a north-westerly direction, for a mile, the surface becomes very rugged and irregular, being broken by deep pits with steeply sloping sides. In

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this rough country, gypsum may be seen in numerous outcrops, being usually soft and crumbling from the effect of weathering, but in some cases it is still quite hard. The height of the tops of the knolls in this hilly area is about thirty-five feet above the eastern level plain, or sixty feet above Lake St. Martin. The breadth of the hilly country was not determined, but an Indian who accompanied us stated that it extended in a south-westerly direction, as far as a certain point on our journey of that day, which was about a mile and a half distant from where we were then standing, beyond which the level country began again.

In a north-westerly direction the ridge was followed for two miles further, to a rather conspicuous hill a short distance north of the Ninth Base Line in section 2, township 33, range 9, west of the Principal Meridian. In this distance it appeared to be broken through by considerable gaps in several places, but where it was well marked, it invariably showed the irregular surface so characteristic of country underlain by gypsum deposits. In many places, small caves would extend in from the bottoms or sides of the pits, some of which held beautifully clear, cold water, a luxury of which we were able to appreciate the value, after tramping for the greater part of a sweltering July day through meadows, forests and swamps, where the mosquitoes and black flies did not attempt to treat us any the more tenderly because we were strangers.

This country is a famous winter hunting-ground for the Indians, for in the autumn the bears retire to these caves, as being comfortable quarters in which to pass the time until the following spring, and many of them are killed every year. Around the mouths of several of the caves could be seen marks of the axe, where the hunter had been obliged to widen the entrances to the cave to be able to get into it to secure his prey. The thickness of the exposures of gypsum in these holes and caves was nowhere very great, ranging as a rule from three feet to six feet six inches, but in none of them was the total thickness of the deposit seen.

The hill at the furthest point to which the ridge was fol-

lowed, rises as a rounded knob, twenty feet above its general level. This hill, like the others, appears to be composed of gypsum, as on its sides are holes extending down twenty feet below its top in which beds of gypsum are well exposed.

In the north-west corner of township 32, range 8, west of the Principal Meridian, is a rounded hill rising thirty-five feet above the plain, its greatest length being about 600 feet, and its greatest breadth 150 feet. Its surface is overgrown with small canoe-birch. Two holes, each about eight feet deep, have been dug by prospectors in this hill. One at the top shows, below a foot of decomposed material, seven feet of hard, compact, white anhydrite or "bull plaster," exhibiting a more or less nodular structure, and breaking on the surface into small irregular fragments. Very little bedding can be detected in the mass. The other hole is in the side of the hill fifteen feet lower down, and shows on top two and a half feet of white clay, consisting of decomposed anhydrite, below which is five and a half feet of white nodular anhydrite similar to that in the other hole. This gives a thickness, almost certainly, of twenty-two feet of this rock, and it is not improbable that the hill is composed entirely of it.

Again, just north of the Ninth Base Line, and two miles east of the township corner, between ranges 8 and 9, is a poplar-covered hill or ridge, thirty feet high. In various places on this hill are exposures of snow-white gypsum, similar to what has been described above, showing in some cases a thickness of ten feet in one section. The most of it is massive or crypto-crystalline, and lies in regular beds which dip slightly towards the west. Some of the beds or layers, however, consist of beautifully crystalline, clear, colourless selenite, which is easily broken out in lamellar masses of considerable size. This is the mineral which in the west, has been so often mistaken for mica.

The above is a brief statement of the known extent of the deposits of gypsum in this district, but it is highly probable that further investigation will prove them to extend over a much larger area. The Indians of the

Saskatchewan Band, who live on the western shore of Lake St. Martin, informed me that similar rock was to be found in several places further north, and they have named a lake on a tributary of Warpath River, which flows into Lake Winnipeg north of the mouth of the Little Saskatchewan, Ka-ka-wusk Sa-ka-higan (translated in English as Mica Lake) from the alleged presence of selenite in its vicinity.

Towards the south-west, at a distance of ninety miles in a straight line, in the bore that was sunk on the bank of Vermilion River by the Manitoba Oil Company, a bed of gypsum fifteen feet in thickness was struck between 550 and 565 feet, at approximately the same geological horizon as that of the gypsum beds above described. Gypsum deposits are therefore in all probability very widely distributed throughout Northern Manitoba.

As far as examined they preserve a pretty constant character. Where they immediately underlie the surface the country is very rough and hilly, and the prevailing poplar of the region is mixed with birch, or the spruce of the adjoining low-lying land is replaced by Banksian pine. The gypsum itself is generally very pure, of a dead white colour, and usually stratified in rather thin beds, which are either horizontal or dipping at a low angle. Among the massive beds, however, are many others, composed of crystals or crystal-masses, in which the crystals usually stand transverse to the plains of bedding. Some plates could doubtless be obtained from the crystal-masses sufficiently clear for optical purposes. No anhydrite was seen mixed with the gypsum, but one of the hills, as above stated, appeared to be composed entirely of it. It is much harder and tougher than the gypsum or hydrated sulphate of lime, is considerably heavier, has a roughly nodular, rather than a distinctly stratified structure, and is of a decidedly bluish tint.

Of the exact geological age of the deposit it is difficult to speak as yet with certainty, as the strata have not been continuously traced into any others, and no beds im-

mediately under or overlying them have been seen. There is little doubt, however, that they occupy either the summit of the Silurian or the base of the Devonian limestones. All the evidence that we have on the point has not as yet been perfectly elaborated, but it consists in the general horizontality of the beds wherever seen throughout the whole area, and in the existence of limestones holding fossils on Lake Manitoba, twelve miles distant in a south-westerly direction, and of limestones holding fossils on Lake St. Martin, eleven miles distant in a south-easterly direction. Also reference might be made to the above-mentioned bore on Vermilion River, where the gypsum was at the base of a bed of Devonian limestone one hundred and thirty feet in thickness. Thus these deposits are practically of about the age of the Onondaga Formation of New York and Western Ontario, in which rocks plaster-quarries have been worked for many years. This Formation also contains the great salt deposits of Ontario, and it is a significant fact, that a short distance to the west of the area under consideration, around the shores of lakes Manitoba and Winnipegosis, many brine springs are known to occur. In the State of Michigan, many of the plaster-quarries are also in rocks of about the same age. In Nova Scotia, the gypsum deposits are of lower Carboniferous age, and in Iowa they are stated to belong to a still higher horizon.

The general hilly and irregular character of the surface underlain by the plaster beds, and the fact that isolated hills of gypsum rise above the surface of the otherwise level plain, make it appear probable that the deposits occur as lenticular masses in the beds of limestone which seem to compose the general floor of this whole area, though in most places the limestone is covered either by a mass of glacial till, or by the alluvial deposits laid down on the bottom of the ancient Lake Agassiz. The gypsum also resembles the limestone in being clearly stratified horizontally or at a very low angle. Besides this, some of the limestone of Northern Manitoba contains a large amount of sulphur scattered throughout its mass in the

form of very minute grains of iron pyrites. The iron pyrites readily oxidises into a sulphate or double sulphate of iron which combining with the carbonate of lime give as products of the double decomposition, sulphate of lime or gypsum, and carbonate or possibly sulphate of iron. In the Cretaceous shales of the Duck and Riding Mountains and of the Plains further west, this process is clearly seen to have gone on. Iron pyrites is constantly present, and the shells of Inocerami, Ammonites, Baculites, &c., furnish an abundant supply of carbonate of lime. This shale is therefore often filled with minute, or sometimes even large crystals of gypsum, and side by side with them are masses of ironstone or impure carbonate of iron, which, after being formed in the above-described way, has collected in rounded or lenticular nodules about a shell, fragment of a crayfish, or other nucleus. In the case of the Paleozoic limestones, however, no trace is found of the carbonate or other salt of iron which would have resulted from the double decomposition, and if it was ever formed in the rock, it has since been dissolved away by water percolating through the strata.

The gypsum may, however, have been formed in a different way. The whole of this country has undoubtedly suffered very considerable erosion since Cretaceous times, the shales and marls of the Duck and Riding Mountains having almost certainly extended much further east than Lake St. Martin. Many of the springs that now flow from these shales are strongly impregnated with sulphuretted hydrogen, which might readily be oxidized into sulphuric acid. This acid acting slowly on the beds of limestone would alter them into sulphate of lime without disturbing the stratification at all.

Of the uses of gypsum it is unnecessary to speak. In the Western States, where the air is dry and atmospheric erosion is very small, it is used as a building stone, being very easily worked, and sufficiently durable and strong for residences and all ordinary buildings.

By roasting, its water of crystallization is driven off and

it is reduced to the fine powder commonly known as Plaster of Paris. By grinding the crude gypsum as it comes from the quarries between ordinary burr-stones, land-plaster is obtained, a substance of which it is difficult to over-estimate the value in a country whose resources are almost entirely agricultural. The soil of Manitoba and the North-West Territories is very fertile now, but a time will come when having raised crop after crop it will need replenishing. The value of this extensive gypsum deposit will then be thoroughly realised. Lying as it does within twelve miles of Lake Manitoba, a navigable stretch of open water extending southward almost to the Manitoba and North-Western Railway, it can readily be brought to all parts of the province. It is also on the line of the projected railway from Winnipeg, between Lakes Winnipeg and Manitoba, to Hudson's Bay, and by this railway would be within one hundred and fifty miles from Winnipeg, and as the intervening country is very level, the cost of carrying it there would not be great.

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